Practitioner's Docket No. 442-008422-US(PAR) **PATENT**

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Box Patent Application
Assistant Commissioner for Patents
Washington, D.C. 20231

NEW APPLICATION TRANSMITTAL

Transmitted herewith for filing is the patent application of

Inventor(s): Ville RUUTU, Timo RANTALAINEN, Marko ALANEN, Gudni GUNNARSON
Olli HYVARINEN

WARNING: 37 C.F.R. § 1.41(a)(1) points out:

"(a) A patent is applied for in the name or names of the actual inventor or inventors.

"(1) The inventorship of a nonprovisional application is that inventorship set forth in the oath or declaration as prescribed by § 1.63, except as provided for in § 1.53(d)(4) and § 1.63(d). If an oath or declaration as prescribed by § 1.63 is not filed during the pendency of a nonprovisional application, the inventorship is that inventorship set forth in the application papers filed pursuant to § 1.53(b), unless a petition under this paragraph accompanied by the fee set forth in § 1.17(i) is filed supplying or changing the name or names of the inventor or inventors."

For (title): CELLULAR RADIO POSITIONING

CERTIFICATION UNDER 37 C.F.R. 1.10*
(Express Mail label number is mandatory.)
(Express Mail certification is optional.)

I hereby certify that this New Application Transmittal and the documents referred to as attached therein are being deposited with the United States Postal Service on this date January 14, 1999, in an envelope as "Express Mail Post Office to Addressee," mailing Label Number EL067101085US, addressed to the: Assistant Commissioner for Patents, Washington, D.C. 20231.

Shauna Murphy
(type or print name of person mailing paper)

Shauna Murphy
Signature of person mailing paper

WARNING: Certificate of mailing (first class) or facsimile transmission procedures of 37 C.F.R. 1.8 cannot be used to obtain a date of mailing or transmission for this correspondence.

*"WARNING: Each paper or fee filed by "Express Mail" **must** have the number of the "Express Mail" mailing label placed thereon prior to mailing. 37 C.F.R. 1.10(b).*
*"Since the filing of correspondence under § 1.10 without the Express Mail mailing label thereon is an oversight that can be avoided by the exercise of reasonable care, requests for waiver of this requirement will **not** be granted on petition." Notice of Oct. 24, 1996, 60 Fed. Reg. 56,439, at 56,442.*

1. Type of Application

This new application is for a(n)

(check one applicable item below)

☒ Original (nonprovisional)

☐ Design

☐ Plant

WARNING: Do not use this transmittal for a completion in the U.S. of an International Application under 35 U.S.C. 371(c)(4), unless the International Application is being filed as a divisional, continuation or continuation-in-part application.

WARNING: Do not use this transmittal for the filing of a provisional application.

NOTE: If one of the following 3 items apply, then complete and attach ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF A PRIOR U.S. APPLICATION CLAIMED and a NOTIFICATION IN PARENT APPLICATION OF THE FILING OF THIS CONTINUATION APPLICATION.

☐ Divisional.

☐ Continuation.

☐ Continuation-in-part (C-I-P).

2. Benefit of Prior U.S. Application(s) (35 U.S.C. 119(e), 120, or 121)

NOTE: A nonprovisional application may claim an invention disclosed in one or more prior filed copending nonprovisional applications or copending international applications designating the United States of America. In order for a nonprovisional application to claim the benefit of a prior filed copending nonprovisional application or copending international application designating the United States of America, each prior application must name as an inventor at least one inventor named in the later filed nonprovisional application and disclose the named inventor's invention claimed in at least one claim of the later filed nonprovisional application in the manner provided by the first paragraph of 35 U.S.C. 112. Each prior application must also be:

(i) An international application entitled to a filing date in accordance with PCT Article 11 and designating the United States of America; or

(ii) Complete as set forth in § 1.51(b); or

(iii) Entitled to a filing date as set forth in § 1.53(b) or § 1.53(d) and include the basic filing fee set forth in § 1.16; or

(iv) Entitled to a filing date as set forth in § 1.53(b) and have paid therein the processing and retention fee set forth in § 1.21(l) within the time period set forth in § 1.53(f).

37 C.F.R. § 1.78(a)(1).

NOTE: If the new application being transmitted is a divisional, continuation or a continuation-in-part of a parent case, or where the parent case is an International Application which designated the U.S., or benefit of a prior provisional application is claimed, then check the following item and complete and attach ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED.

WARNING: If an application claims the benefit of the filing date of an earlier filed application under 35 U.S.C. 120, 121 or 365(c), the 20-year term of that application will be based upon the filing date of the earliest U.S. application that the application makes reference to under 35 U.S.C. 120, 121 or 365(c). (35 U.S.C. 154(a)(2) does not take into account, for the determination of the patent term, any application on which priority is claimed under 35 U.S.C. 119, 365(a) or 365(b).) For a c-i-p application, applicant should review whether any claim in the patent that will issue is supported by an earlier application and, if not, the applicant should consider canceling the reference to the earlier filed application. The term of a patent is not based on a claim-by-claim approach. See Notice of April 14, 1995, 60 Fed. Reg. 20,195, at 20,205.

WARNING: When the last day of pendency of a provisional application falls on a Saturday, Sunday, or Federal holiday within the District of Columbia, any nonprovisional application claiming benefit of the provisional application must be filed prior to the Saturday, Sunday, or Federal holiday within the District of Columbia. See 37 C.F.R. § 1.78(a)(3).

☐ The new application being transmitted claims the benefit of prior U.S. application(s). Enclosed are ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED.

3. Papers Enclosed

A. Required for filing date under 37 C.F.R. § 1.53(b) (Regular) or 37 C.F.R. § 1.153 (Design) Application

10 Pages of specification

2 Pages of claims

2 Sheets of drawing

WARNING: DO NOT submit original drawings. A high quality copy of the drawings should be supplied when filing a patent application. The drawings that are submitted to the Office must be on strong, white, smooth, and non-shiny paper and meet the standards according to § 1.84. If corrections to the drawings are necessary, they should be made to the original drawing and a high-quality copy of the corrected original drawing then submitted to the Office. Only one copy is required or desired. For comments on proposed then-new 37 CFR 1.84, see Notice of March 9, 1988 (1990 O.G. 57-62).

NOTE: "Identifying indicia, if provided, should include the application number or the title of the invention, inventor's name, docket number (if any), and the name and telephone number of a person to call if the Office is unable to match the drawings to the proper application. This information should be placed on the back of each sheet of drawing a minimum distance of 1.5 cm. (5/8 inch) down from the top of the page . . ." 37 C.F.R. 1.84(c)).

(complete the following, if applicable)

☐ The enclosed drawing(s) are photograph(s), and there is also attached a "PETITION TO ACCEPT PHOTOGRAPH(S) AS DRAWING(S)." 37 C.F.R. 1.84(b).

☐ formal

☐ informal

B. Other Papers Enclosed

____ Pages of declaration and power of attorney

1 Pages of abstract

____ Other

4. Additional papers enclosed

☐ Amendment to claims

☐ Cancel in this applications claims _____ before calculating the filing fee. (At least one original independent claim must be retained for filing purposes.)

☐ Add the claims shown on the attached amendment. (Claims added have been numbered consecutively following the highest numbered original claims.)

☒ Preliminary Amendment

☒ Information Disclosure Statement (37 C.F.R. 1.98)

☒ Form PTO–1449 (PTO/SB/08A and 08B)

☒ Citations

☐ Declaration of Biological Deposit

☐ Submission of "Sequence Listing," computer readable copy and/or amendment pertaining thereto for biotechnology invention containing nucleotide and/or amino acid sequence.

☐ Authorization of Attorney(s) to Accept and Follow Instructions from Representative

☐ Special Comments

☐ Other

5. Declaration or oath (including power of attorney)

NOTE: A newly executed declaration is not required in a continuation or divisional application provided that the prior nonprovisional application contained a declaration as required, the application being filed is by all or fewer than all the inventors named in the prior application, there is no new matter in the application being filed, and a copy of the executed declaration filed in the prior application (showing the signature or an indication thereon that it was signed) is submitted. The copy must be accompanied by a statement requesting deletion of the names of person(s) who are not inventors of the application being filed. If the declaration in the prior application was filed under § 1.47, then a copy of that declaration must be filed accompanied by a copy of the decision granting § 1.47 status or, if a nonsigning person under § 1.47 has subsequently joined in a prior application, then a copy of the subsequently executed declaration must be filed. See 37 C.F.R. §§ 1.63(d)(1)–(3).

NOTE: A declaration filed to complete an application must be executed, identify the specification to which it is directed, identify each inventor by full name including family name and at least one given name, without abbreviation together with any other given name or initial, and the residence, post office address and country or citizenship of each inventor, and state whether the inventor is a sole or joint inventor. 37 C.F.R. § 1.63(a)(1)–(4).

☐ Enclosed

Executed by

(check all *applicable boxes)*

☐ inventor(s).

☐ legal representative of inventor(s). 37 CFR 1.42 or 1.43.

☐ joint inventor or person showing a proprietary interest on behalf of inventor who refused to sign or cannot be reached.

☐ This is the petition required by 37 CFR 1.47 and the statement required by 37 CFR 1.47 is also attached. See item 13 below for fee.

☒ Not Enclosed.

NOTE: Where the filing is a completion in the U.S. of an International Application or where the completion of the U.S. application contains subject matter in addition to the International Application, the application may be treated as a continuation or continuation-in-part, as the case may be, utilizing ADDED PAGE FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION CLAIMED.

☒ Application is made by a person authorized under 37 C.F.R. 1.41(c) on behalf of *all* the above named inventor(s).

(The declaration or oath, along with the surcharge required by 37 CFR 1.16(e) can be filed subsequently).

☐ Showing that the filing is authorized. *(not required unless called into question. 37 CFR 1.41(d))*

6. Inventorship Statement

WARNING: If the named inventors are each not the inventors of all the claims an explanation, including the ownership of the various claims at the time the last claimed invention was made, should be submitted.

The inventorship for all the claims in this application are:

☐ The same.

or

☐ Not the same. An explanation, including the ownership of the various claims at the time the last claimed invention was made,

☐ is submitted.

☐ will be submitted.

7. Language

NOTE: An application including a signed oath or declaration may be filed in a language other than English. An English translation of the non-English language application and the processing fee of $130.00 required by 37 CFR 1.17(k) is required to be filed with the application, or within such time as may be set by the Office. 37 CFR 1.52(d).

☒ English

☐ Non-English

☐ The attached translation includes a statement that the translation is accurate. 37 C.F.R. 1.52(d).

8. Assignment

☒ An assignment of the invention to Nokia Mobile Phones Limited

☐ is attached. A separate ☐ "COVER SHEET FOR ASSIGNMENT (DOCUMENT) ACCOMPANYING NEW PATENT APPLICATION" or ☐ FORM PTO 1595 is also attached.

☒ will follow.

NOTE: "If an assignment is submitted with a new application, send two separate letters-one for the application and one for the assignment." Notice of May 4, 1990 (1114 O.G. 77-78).

WARNING: A newly executed "CERTIFICATE UNDER 37 CFR 3.73(b)" must be filed when a continuation-in-part application is filed by an assignee. Notice of April 30, 1993, 1150 O.G. 62-64.

9. Certified Copy

Certified copy(ies) of application(s)

Country	Appln. No.	Filed
Finland	980077	January 15, 1998
Country	Appln. No.	Filed
Country	Appln. No.	Filed

from which priority is claimed

☒ is (are) attached.

☐ will follow.

NOTE: The foreign application forming the basis for the claim for priority must be referred to in the oath or declaration. 37 CFR 1.55(a) and 1.63.

NOTE: This item is for any foreign priority for which the application being filed directly relates. If any parent U.S. application or International Application from which this application claims benefit under 35 U.S.C. 120 is itself entitled to priority from a prior foreign application, then complete item 18 on the ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED.

10. Fee Calculation (37 C.F.R. 1.16)

A. ☒ Regular application

CLAIMS AS FILED				
Number filed		Number Extra	Rate	Basic Fee 37 C.F.R. 1.16(a) $760.00
Total Claims (37 CFR 1.16(c))	8 − 20 =	0	× $ 18.00	
Independent Claims (37 CFR 1.16(b))	3 − 3 =	0	× $ 78.00	
Multiple dependent claim(s), if any (37 CFR 1.16(d))			+ $ 260.00	

☐ Amendment cancelling extra claims is enclosed.

☒ Amendment deleting multiple-dependencies is enclosed.

☐ Fee for extra claims is not being paid at this time.

NOTE: If the fees for extra claims are not paid on filing they must be paid or the claims cancelled by amendment, prior to the expiration of the time period set for response by the Patent and Trademark Office in any notice of fee deficiency. 37 CFR 1.16(d).

Filing Fee Calculation $ 760.00

B. ☐ Design application
($ 310.00—37 CFR 1.16(f))

Filing Fee Calculation $_____

C. ☐ Plant application
($ 480.00—37 CFR 1.16(g))

Filing fee calculation $_____

11. **Small Entity Statement(s)**

☐ Statement(s) that this is a filing by a small entity under 37 CFR 1.9 and 1.27 is (are) attached.

WARNING: "Status as a small entity must be specifically established in each application or patent in which the status is available and desired. Status as a small entity in one application or patent does not affect any other application or patent, including applications or patents which are directly or indirectly dependent upon the application or patent in which the status has been established. The refiling of an application under § 1.53 as a continuation, division, or continuation-in-part (including a continued prosecution application under § 1.53(d)), or the filing of a reissue application requires a new determination as to continued entitlement to small entity status for the continuing or reissue application. A nonprovisional application claiming benefit under 35 U.S.C. 119(e), 120, 121, or 365(c) of a prior application, or a reissue application may rely on a statement filed in the prior application or in the patent if the nonprovisional application or the reissue application includes a reference to the statement in the prior application or in the patent or includes a copy of the statement in the prior application or in the patent and status as a small entity is still proper and desired. The payment of the small entity basic statutory filing fee will be treated as such a reference for purposes of this section." 37 C.F.R. § 1.28(a)(2).

(complete the following, if applicable)

☐ Status as a small entity was claimed in prior application

_____ / _____, filed on _____, from which benefit is being claimed for this application under:

35 U.S.C. ☐ 119(e),
☐ 120,
☐ 121,
☐ 365(c),

and which status as a small entity is still proper and desired.

☐ A copy of the statement in the prior application is included.

Filing Fee Calculation (50% of A, B or C above)

$_____

NOTE: Any excess of the full fee paid will be refunded if small entitiy status is established and a refund request are filed within 2 months of the date of timely payment of a full fee. The two-month period is not extendable under § 1.136. 37 CFR 1.28(a).

12. **Request for International-Type Search** (37 C.F.R. 1.104(d))

(complete, if applicable)

☐ Please prepare an international-type search report for this application at the time when national examination on the merits takes place.

13. **Fee Payment Being Made at This Time**

☐ Not Enclosed

☐ No filing fee is to be paid at this time.
(This and the surcharge required by 37 C.F.R. 1.16(e) can be paid subsequently.)

☒ Enclosed

☒ Filing fee	$ 760.00
☐ Recording assignment ($40.00; 37 C.F.R. 1.21(h)) (See attached "COVER SHEET FOR ASSIGNMENT ACCOMPANYING NEW APPLICATION".)	$ _____
☐ Petition fee for filing by other than all the inventors or person on behalf of the inventor where inventor refused to sign or cannot be reached ($130.00; 37 C.F.R. 1.47 and 1.17(i))	$ _____
☐ For processing an application with a specification in a non-English language ($130.00; 37 C.F.R. 1.52(d) and 1.17(k))	$ _____
☐ Processing and retention fee ($130.00; 37 C.F.R. 1.53(d) and 1.21(l))	$ _____
☐ Fee for international-type search report ($40.00; 37 C.F.R. 1.21(e))	$ _____

NOTE: 37 CFR 1.21(l) establishes a fee for processing and retaining any application that is abandoned for failing to complete the application pursuant to 37 CFR 1.53(f) and this, as well as the changes to 37 CFR 1.53 and 1.78(a)(1), indicate that in order to obtain the benefit of a prior U.S. application, either the basic filing fee must be paid, or the processing and retention fee of § 1.21(l) must be paid, within 1 year from notification under § 53(f).

Total fees enclosed $ 760.00

14. **Method of Payment of Fees**

☒ Check in the amount of $ 760.00

☐ Charge Account No. _____ in the amount of $_____

A duplicate of this transmittal is attached.

NOTE: Fees should be itemized in such a manner that it is clear for which purpose the fees are paid. 37 CFR 1.22(b).

15. Authorization to Charge Additional Fees

WARNING: *If no fees are to be paid on filing, the following items should not be completed.*

WARNING: *Accurately count claims, especially multiple dependent claims, to avoid unexpected high charges, if extra claim charges are authorized.*

☒ The Commissioner is hereby authorized to charge the following additional fees by this paper and during the entire pendency of this application to Account No. 16-1350 :

☒ 37 C.F.R. 1.16(a), (f) or (g) (filing fees)

☒ 37 C.F.R. 1.16(b), (c) and (d) (presentation of extra claims)

NOTE: *Because additional fees for excess or multiple dependent claims not paid on filing or on later presentation must only be paid or these claims cancelled by amendment prior to the expiration of the time period set for response by the PTO in any notice of fee deficiency (37 CFR 1.16(d)), it might be best not to authorize the PTO to charge additional claim fees, except possibly when dealing with amendments after final action.*

☒ 37 C.F.R. 1.16(e) (surcharge for filing the basic filing fee and/or declaration on a date later than the filing date of the application)

☒ 37 C.F.R. §§ 1.17(a)(1)–(5) (extension fees pursuant to § 1.136(a)).

☐ 37 C.F.R. 1.17 (application processing fees)

NOTE: *". . . A written request may be submitted in an application that is an authorization to treat any concurrent or future reply, requiring a petition for an extension of time under this paragraph for its timely submission, as incorporating a petition for extension of time for the appropriate length of time. An authorization to charge all required fees, fees under § 1.17, or all required extension of time fees will be treated as a constructive petition for an extension of time in any concurrent or future reply requiring a petition for an extension of time under this paragraph for its timely submission. Submission of the fee set forth in § 1.17(a) will also be treated as a constructive petition for an extension of time in any concurrent reply requiring a petition for an extension of time under this paragraph for its timely submission." 37 C.F.R. § 1.136(a)(3).*

☐ 37 C.F.R. 1.18 (issue fee at or before mailing of Notice of Allowance, pursuant to 37 C.F.R. 1.311(b))

NOTE: *Where an authorization to charge the issue fee to a deposit account has been filed before the mailing of a Notice of Allowance, the issue fee will be automatically charged to the deposit account at the time of mailing the notice of allowance. 37 CFR 1.311(b).*

NOTE: *37 CFR 1.28(b) requires "Notification of any change in status resulting in loss of entitlement to small entity status must be filed in the application . . . prior to paying, or at the time of paying, . . . the issue fee. . . ." From the wording of 37 CFR 1.28(b), (a) notification of change of status must be made even if the fee is paid as "other than a small entity" and (b) no notification is required if the change is to another small entity.*

16. Instructions as to Overpayment

NOTE: ". . . Amounts of twenty-five dollars or less will not be returned unless specifically requested within a reasonable time, nor will the payer be notified of such amounts; amounts over twenty-five dollars may be returned by check or, if requested, by credit to a deposit account." 37 C.F.R. § 1.26(a).

☒ Credit Account No. 16-1350

☐ Refund

SEND ALL CORRESPONDENCE TO:

SIGNATURE OF PRACTITIONER

Reg. No. 24,622

Clarence A. Green

(type or print name of attorney)

Tel. No. (203) 259-1800

PERMAN & GREEN, LLP

P.O. Address

425 Post Road
Fairfield, CT 06430

Customer No.

☐ **Incorporation by reference of added pages**

(check the following item if the application in this transmittal claims the benefit of prior U.S. application(s) (including an international application entering the U.S. stage as a continuation, divisional or C-I-P application) and complete and attach the ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED)

☐ Plus Added Pages for New Application Transmittal Where Benefit of Prior U.S. Application(s) Claimed

Number of pages added _____

☐ Plus Added Pages for Papers Referred to in Item 4 Above

Number of pages added _____

☐ Plus added pages deleting names of inventor(s) named in prior application(s) who is/are no longer inventor(s) of the subject matter claimed in this application.

Number of pages added _____

☐ Plus "Assignment Cover Letter Accompanying New Application"

Number of pages added _____

☒ **Statement Where No Further Pages Added**

(if no further pages form a part of this Transmittal, then end this Transmittal with this page and check the following item)

☒ This transmittal ends with this page.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Express Mail No. EL067101085US

In re Application of : RUUTU et al.

SERIAL NUMBER: EXAMINER:

FILING DATE: Herewith ART UNIT:

TITLE: CELLULAR RADIO POSITIONING

ATTORNEY DOCKET NO.: 442-008422-US(PAR)

The Commissioner of Patents and Trademarks

Washington, D. C. 20231

PRELIMINARY AMENDMENT

Dear Sir:

Please amend the above-identified, enclosed patent application as follows:

IN THE CLAIMS:

Please amend Claims 3, 5 and 6 as shown below.

Claim 3, line 1, delete "or 2".

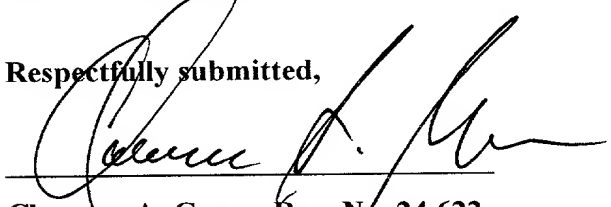
Claim 5, line 1, delete "or 4".

Claim 6, line 1, delete "any one of the preceding claims" and insert --claim 1--.

REMARKS

Prior to calculation of the fees, please enter this preliminary amendment.

Respectfully submitted,



12 Jan 99

Clarence A. Green, Reg. No. 24,622 Date

PERMAN & GREEN, LLP

425 Post Road

Fairfield, CT 06430 (203) 259-1800

CELLULAR RADIO POSITIONING

FIELD OF THE INVENTION

The present invention relates to a method and apparatus for determining the position of a mobile communications device in a cellular radio telephone network.

BACKGROUND OF THE INVENTION

A cellular radio telephone network is made up of Base Transceiver Stations (BTS) each serving a corresponding, geographical "cell" area. Groups of several adjacent cells are organised into what are known as "Location Areas" (LA). If the MS is actively communicating with the network, e.g. the user is conducting a telephone call, the actual cell within the LA in which the MS is present is known to the network. However, when the MS is switched on but not actively used (i.e. it is IDLE or "camping"), the network only knows the LA but not the actual cell in which the MS is present. Cell sizes vary considerably and even if the network knows the cell in which the MS is present the position of the MS can only be identified with a resolution equal to the cell size.

Future cellular systems may be required to determine the position of a MS with a considerably better precision than can currently be obtained. For example, the United States Federal Communication Commission (FCC) has specified that when a MS is used to make an emergency call the network must be able to locate the MS with an accuracy of 125 meters in 67 percent of cases. Such precise position determination has many other desirable applications such as for taxi dispatch and for monitoring the whereabouts of vehicles, objects and persons etc.

One possible way to provide the necessary precision is to incorporate a satellite based positioning system, like the Global Positioning System (GPS), into a MS. GPS can be used almost without geographical restrictions, but this solution is complex and increases the cost, size and power consumption of a MS. Moreover, GPS has additional problems including; low signal levels inside buildings, the difficulty in obtaining a clear path to at least three satellites in built-up urban areas, and the relatively long time to obtain a first GPS positional fix after switch-on.

It appears that a cellular MS locating system based on the cellular radio system offers the best and most practical solution. A number of proposals have been made based either on direction finding, field strength or time measurements. In particular, proposals have been made which rely upon determining the position of

a MS from information transmitted to the MS from BTSs serving the cell in which the MS is present and/or adjacent cells.

One proposal includes triangulation of the position of a MS using at least two direction finding receivers within the network, e.g. incorporated into respective BTSs. Within built-up urban areas, multipath signals will degrade position precision unless the disturbing multipath distortion is removed from observed signals. However, good direction finding receivers having this capability are expensive and bulky and as such this method is unlikely to be suitable for large-scale cellular radio locating.

A second proposal relies upon measuring the relative field strengths of signals received at a MS from at least three BTSs. However, it will be appreciated that field strength is likely to vary considerable and in an unpredictable manner over the geographical coverage area of a BTS. This renders the method unsuitable in practise for cellular radio positioning.

A third proposal requires measurement of time delays in signals transmitted to a MS from several adjacent BTSs (or *vice versa*). Measured delays are converted into respective distances and a simple circle intersecting method can be used to determine a MS position. Such a position determining method, adapted for the GSM cellular radio system, is described for example in WO 92/05672 and WO 97/27711. The methods makes use of transmission Time Advance (TA) values already calculated in GSM transmissions in order to ensure synchronisation of MSs to BTSs (i.e. so that transmissions from a MS arrive at a BTS in the right time slot regardless of the distance between the MS and the BTS). Figure 1 illustrates a TA value based position determining method.

Figure 2 illustrates another time delay based positioning system in which Observed Time Differences (OTD) are utilised. EP0767594 describes such a system adapted for the GSM cellular radio system. The system has the advantage that OTDs can be obtained without having to register the MS with all of the BTSs used for position determination, as is the case with the TA value based systems.

Time delay based systems provide a cost-effective and simple solution to the problem of providing high accuracy position determination. However, accuracy is critically dependent upon the position of the BTSs relative to a MS whose position

is to be determined. Figure 3a illustrates an example of a good measurement geometry, where each pair of BTSs locates a MS along a hyperbola, and the set of hyperbolas intersect with large contact angles. In contrast, Figure 3b illustrates an example of a bad measurement geometry where the hyperbolas intersect with small contact angles.

SUMMARY OF THE INVENTION

It is an object of the present invention to overcome or at least mitigate the above noted disadvantages. The present invention achieves this and other objects by dynamically notifying a MS of BTSs suitable for position determination purposes, whenever the position of the MS is to be determined, or by notifying the MS of BTSs to be excluded from use in such determinations.

According to a first aspect of the present invention there is provided a method of determining the position of a mobile communications device within a cellular network, the method comprising the steps of:

transmitting data to the mobile communication device from the cellular network, said data identifying to the mobile communication device a list of radio channels corresponding to respective radio transmitters of the cellular network, said list being determined on the basis of the approximate position of the mobile communication device; and

causing the mobile communication device to listen on said identified channels, or on other channels excluding said identified channels, and to determine from information transmitted over the listened to channels data values related to the relative geometry of the mobile communication device and the radio transmitters transmitting the listened to channels; and

determining the position of the mobile communication device using said determined data values.

By forcing a mobile communications device to use preselected radio transmitters for position determination measurements, or by excluding certain radio transmitters, the measurement process may be optimised for any given geographical area. The choice of radio transmitters to be used is not left solely to the mobile device and the risk of selecting radio transmitters having a poor measurement geometry, or other disadvantageous properties, is reduced.

Preferably, said transmitters are provided by respective base transceiver stations and the data transmitted to the mobile device identifying the list of radio channels comprises a set of radio channel numbers known to the mobile device.

Preferably, said data values are time relationship values related to the transmission delay times between the mobile device and the radio transmitters transmitting the listened to channels. More preferably, the time relationship values are Observed Time Differences (OTD). Each OTD is the difference between the transmission delay time between the mobile device and one of the radio transmitters transmitting the listened to channels, and the transmission delay time between the mobile device and a radio transmitter of a base transceiver station currently serving the mobile device.

In alternative embodiments of the present invention, the time relationship values are Timing Advance (TA) values equal to twice the transmission delay time between the mobile device and respective ones of the radio transmitters transmitting the listened to channels.

Preferably, said time relationship values are sent by the mobile communications device to the network where said determining step is carried out.

The present invention may also be applied to other position determining methods such as those involving relative field strength measurements and direction finding.

In preferred embodiments of the present invention, the list of radio channels identified to the mobile device contains those channels which the mobile device should try to listen to in order to obtain said data values from which the position of the mobile device can be determined. In some circumstances, a mobile device may only be able to receive said transmitted information from a sub-set of the listed channels (e.g. because the signal level of the other channels is too low at the mobile device). However, providing that a minimum number of channels can be adequately received (e.g. two) it may still be possible to determine the position of the mobile device.

In other embodiments of the present invention, the network identifies to the mobile device one or more radio channels which should not be used for position determination. This may be desirable, for example, to exclude the use of multiple radio transmitters at the same location. A mobile device may then itself select

suitable radio channels, excluding the identified channels, by for example scanning the radio spectrum. The radio channels, or transmitters, selected by the mobile device are identified to the network together with the measurement data.

According to a second aspect of the present invention there is provided apparatus for determining the position of a mobile communications device within a cellular network, the apparatus comprising:

a base transceiver station for transmitting data to the mobile communication device from the cellular network, said data identifying to the mobile communication device a list of radio channels corresponding to respective radio transmitters of the cellular network, said list being determined on the basis of the approximate position of the mobile communication device;

a radio receiver at the mobile communication device for listening on said identified channels, or on other channels excluding said identified channels;

first signal processing means coupled to said radio receiver for determining from information transmitted over the listened to channels data values related to the relative geometry of the mobile communication device and the radio transmitters transmitting the listened to channels; and

second signal processing means for computing the position of the mobile communication device using said determined data values.

According to a third aspect of the present invention there is provided a mobile communications device comprising:

a radio receiver for receiving data transmitted from a serving base transceiver station of a cellular radio network, said data identifying to the mobile communication device a list of radio channels corresponding to respective radio transmitters of the cellular network, and said list being determined on the basis of the approximate position of the mobile communication device, and said radio receiver being arranged to listen on said identified channels, or on other channels excluding said identified channels;

first signal processing means coupled to said radio receiver for determining from information transmitted over the listened to channels data values related to the relative geometry of the mobile communication device and the radio transmitters transmitting the listened to channels; and

a radio transmitter for transmitting said determined data values to said serving base transceiver station.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the present invention and in order to show how the same may be carried into effect reference will now be made, by way of example, to the accompanying drawings, in which:

Figure 1 illustrates a Timing Advance value method of determining the position of a MS;

Figure 2 illustrates an Observed Time Difference method of obtaining the position of a MS;

Figure 3 illustrates good and bad base transceiver station geometries for use in the Observed Time Difference method of Figure 2; and

Figure 4 illustrates a GSM system arranged to implement a method embodying the present invention.

DETAILED DESCRIPTION

A typical GSM network that is designed to implement the present invention is shown in Figure 4. The network has *inter alia* Base Transceiver Stations (BTS) 1 to 6, Base Station Controllers (BSC) 7,8 (each BSC controlling a subset of BTSs), a Mobile Switching Centre (MSC) 9 linked to the two BSCs 7,8, and a Short Message Service-Service Centre (SMS-SC) 10.

The network uses a Home Location Register (HLR) and a Visitor Location Register (VLR), not shown in Figure 4, to maintain the status and LA of a MS, or the address of a foreign network if the MS is not registered to its home network. The MSC 9 of the network communicates with additional networks, including a Public Switched Telephone Network (PSTN), through a Gateway MSC (GMSC) 11, and with an Operation and Maintenance Centre (OMC) 12. The OMC 12 maintains and updates information in the network. A Mobile Positioning Centre (MPC) 13 is added to the conventional GSM network architecture and is used by location applications 14,15 which are also additional to the conventional GSM network architecture.

Figure 4 shows a MS 16 which, for the purposes of this explanation, is assumed to be able to receive transmissions from each of BTSs 1 to 6. At any given time, the MS is registered to only one BTS (BTS 6 in Figure 4) which is termed the "serving" BTS. User data and signalling data are communicated between the network and the MS 16 via this serving BTS 6. However, the MS 16 also continuously monitors the level of signals received from the other surrounding BTSs 1 to 5 for the purpose of facilitating a handover, e.g. when the MS 16 crosses from the serving

area of one BTS to that of another BTS. These surrounding BTSs 1 to 5 are identified to the MS 16 by the controlling BSC 8, via the serving BTS 6, when the MS 16 is actively communicating with the network. The MS 16 reports the measured signal levels, over a Slow Associated Control Channel (SACH), to the BSC 8 via the BTS 6. From the received signal levels, the BSC 8 can determine whether the MS 16 should be handed over to another BTS 1 to 5 and/or whether a new "handover" list of BTSs, for monitoring by the MS 16, should be transmitted to the MS 16.

The GSM system is a Time Division Multiple Access (TDMA) based system in which data is transmitted between the network and MSs in time slots allocated to MSs. A TDMA frame is divided into eight time slots. A consequence of this method is the MS 16 must be synchronised with the serving BTS 6 in order to ensure that data transmitted from the MS 16 is received at the BTS 6 in the time slot allocated to the MS 16, and that signals received by the MS 16 are sampled at the correct points in time. Data sent from the BTS 6 to the MS 16 contains synchronisation sequences which are known to the MS 16 and which allow the MS 16 to "lock-on" to the BTS 6 transmissions. The internal clock of the MS 16 is thus synchronised with that of the BTS 6 but with an offset corresponding to the transmission delay time between the serving BTS 6 and the MS 16. The propagation time delay between the MS 16 and the BTS 16 is computed (at regular time intervals) and sent from the BTS 6 to the MS 16 as a Timing Advance Value (TAV) to allow the MS 16 to compensate for the propagation delay in its transmissions.

Assume that one of the network applications 14,15 requests that the position of the MS 16 be determined. This request may be initiated by the MS 16 itself, by the network, or by a remote subscriber or connection, and is passed to the MPC 13. For each BTS, the MPC 13 holds a "locating" list of other BTSs suitable for determining the position of a MS served by that BTS. This information has been provided to the MPC 13 by the OMC 12. Upon receipt of the position determining request, the MPC 13 enquires from the registers (HLR and VLR) in the MSC 9 the status of the MS 16 and, if the MS 16 is active, the serving BTS. If the MS is not currently active, but is reported as switched on, then the MSC 9 will page the BTSs in the LA to determine the serving BTS. The MPC 13 selects the set of BTSs corresponding to the serving BTS and this set or list is transmitted to the MS 16 via the serving BTS 6. The selected location list may identify a minimum of two BTSs. These may be ones of the BTSs already identified in the handover list, i.e.

BTSs 1 to 5, or the location list may include other BTSs. It will be appreciated that BTSs suitable for use in position determination can be relatively remote from the MS 16 as only a unidirectional radio link, from the BTS to the MS 16, is required. The important point is that the identified BTSs have an optimal, or near optimal, geometry for position determination (see Figure 3A).

The MS 16 has a memory for storing the received location list of BTSs. This memory may be the same memory used to store the handover list of BTSs. The MS 16 listens to each of the radio channels (BroadCast CHannels BCCH) of the respective listed BTSs in turn to identify the time of receipt (relative to the MS's internal clock) of known synchronisation sequences. Assuming that synchronisation sequences are transmitted by the serving BTS 6 and one of the listed BTSs at the same time, then the difference in the time of arrival of the sequence at the MS 16 (the Observed Time Difference OTD) would correspond to the difference in the propagation delays between the MS 6 and the two BTSs. This would allow the position of the MS 6 to be placed on a hyperbola as shown in Figure 2. However, it is unlikely that the synchronisation sequences are transmitted by different BTSs at the same time, i.e. there exists a Real Time Difference (RTD) offset between the serving BTS 6 and each listed BTS. The actual propagation delay difference (the Geometric Time Difference GTD) is therefore given by GTD = OTD - RTD.

In order to determine the RTD between the serving BTS 6 and one of the listed BTSs, use is made of a radio terminal whose position is fixed and known to the network. Figure 4 illustrates two such terminals 17,18. As the position of the terminal is known, the GTD for any two BTSs is also known. By obtaining an OTD measurement for a pair of BTSs, the RTD value for that pair can be derived. When an OTD measurement is obtained for the MS 6, whose position is unknown and to be determined, the corresponding GTD can be obtained using the measured OTD and the calculated RTD. A list of neighbouring BSTs for which RTDs are required is sent from the serving BTS to the RTD MSs 17,18. For a more detailed description of this computation, the reader is referred to EP0767594.

As has already been mentioned, Figure 4 shows a system resource 5 termed the Short Message Service-Service Centre SMS-SC. A SMS is a 160 character, text only message format which operates separately from the voice service of the GSM cellular radio network and is specified by an ETSI GSM recommendation.

The recommendation describes the connection of the Service Centre to a Mobile Switching Centre (MSC), such as the MSC 9 in Figure 4, and also describes the operation of the Service Centre (SC) in connection with sending and relaying SMS messages. This existing service may advantageously be used to relay the MS 16 OTD values to the MPC 13 where the values are used to compute the position of the MS 16.

The only significant addition to implement the enhanced cellular radio positioning method described above is thus the MPC 13. The MPC can be implemented as a stand alone application (as shown in Figure 4) or may run for example in the SMS Service Centre 10. In either case, the MPC 13 is a database with embedded control, calculation and maintenance programs handling the tasks initiated by the application programs 14,15. The MPC performs the following steps:

receiving a position determining request from an application 14,15;
requesting the identity of the BTS serving the MS from the GSM system;
selecting a list of BTSs based on the serving BTS identity from the database;
incorporating the selected list in a reporting command;
requesting the GSM system to send the report command to the MS;
waiting for a reply while processing other pending position determining requests;
receiving a reply in the form of a SMS message from the MS via the SMS-SC;
computing a position using the measurements reported by the MS; and
sending the computed position to the applications 14,15.

As an alternative to the use of SMS for sending position data between the serving BTS 6 and the MS 16, data may be transmitted for example on a packet data channel (e.g. in a General Packet Radio Service GPRS) or using an Unstructured Supplementary Data service (USSD).

In some circumstances, a MS may determine OSDs for BTSs of its own accord, e.g. using the handover list. These may then be sent to the network where the position of the mobile is determined. If the determined position is not accurate enough for the purposes of the network, then a list of BTSs may be sent to the MS from the MPS to enable a new set of OSDs to be determined. This iteration could be carried out several times. It is also possible that a MS could be continuously determining OSDs for the BTSs contained in the handover list, or elsewhere. The

current set could then be sent to the network following receipt by the MS of a request for position determination. The iterative process may then be carried out based on the initial approximate determination.

In the embodiment described above, “raw” OTD values are sent to the MPC 13 where the position of the MS 16 is computed. The MS 16 may of course itself compute its own position if it knows the location of the BTSs identified in the location list and the various RTDs. This additional information may be sent to the MS together with the location list or separately on a signalling channel.

In order to improve the accuracy of a position determination measurement, a number of separate measurements may be made using different subsets of BTSs. The MS 16 may receive a first location list, make a first measurement based on this list, then receive a second list, make a second measurement, etc, until an average position measurement of sufficient accuracy is obtained. This averaging method may also be applied to the measurement of RTDs.

In a modification to the embodiment described above, rather than sending a list of BTSs to the MS 16 which should be used in position determination, the network may send a list of BTSs which should not be used. The BTSs used by the MS 16 may then be selected from, for example, the non-excluded BTS contained in the handover list. This modification may be used advantageously to prevent the use of multiple BTSs present at the same location (it is often the case that several BTSs are mounted on the same mast).

The present invention may be used to “tag” moving objects, persons, or animals. In such applications, there is no need for voice communication and the MS hardware may be considerably reduced.

It will be appreciated that whilst the present invention has been illustrated above with reference to the GSM cellular radio telephone standard, the invention is applicable to other cellular telephone standards such as the US CDMA standards and the Japanese PCN standard.

CLAIMS

1. A method of determining the position of a mobile communications device within a cellular network, the method comprising the steps of:

transmitting data to the mobile communication device from the cellular network, said data identifying to the mobile communication device a list of radio channels corresponding to respective radio transmitters of the cellular network, said list being determined on the basis of the approximate position of the mobile communication device; and

causing the mobile communication device to listen on said identified channels, or on other channels excluding said identified channels, and to determine from information transmitted over the listened to channels data values related to the relative geometry of the mobile communication device and the radio transmitters transmitting the listened to channels; and

determining the position of the mobile communication device using said determined data values.

2. A method according to claim 1, wherein said transmitters are provided by respective base transceiver stations and the data transmitted to the mobile device identifying the list of radio channels comprises a set of radio channel numbers known to the mobile device.

3. A method according to claim 1 or 2, wherein said data values are time relationship values related to the transmission delay times between the mobile device and the radio transmitters transmitting the listened to channels.

4. A method according to claim 3, wherein the time relationship values are Observed Time Differences (OTD) each being the difference between the transmission delay time between the mobile device and one of the radio transmitters transmitting the listened to channels, and the transmission delay time between the mobile device and a radio transmitter of a base transceiver station currently serving the mobile device.

5. A method according to claim 3 or 4, wherein said time relationship values are sent by the mobile communications device to the network where said determining step is carried out.

6. A method according to any one of the preceding claims, wherein the list of radio channels identified to the mobile device contains those channels which the mobile device should try to listen to in order to obtain said data values from which the position of the mobile device can be determined.

7. Apparatus for determining the position of a mobile communications device within a cellular network, the apparatus comprising:

a base transceiver station for transmitting data to the mobile communication device from the cellular network, said data identifying to the mobile communication device a list of radio channels corresponding to respective radio transmitters of the cellular network, said list being determined on the basis of the approximate position of the mobile communication device;

a radio receiver at the mobile communication device for listening on said identified channels, or on other channels excluding said identified channels;

first signal processing means coupled to said radio receiver for determining from information transmitted over the listened to channels data values related to the relative geometry of the mobile communication device and the radio transmitters transmitting the listened to channels; and

second signal processing means for computing the position of the mobile communication device using said determined data values.

8. A mobile communications device comprising:

a radio receiver for receiving data transmitted from a serving base transceiver station of a cellular radio network, said data identifying to the mobile communication device a list of radio channels corresponding to respective radio transmitters of the cellular network, and said list being determined on the basis of the approximate position of the mobile communication device, and said radio receiver being arranged to listen on said identified channels, or on other channels excluding said identified channels;

first signal processing means coupled to said radio receiver for determining from information transmitted over the listened to channels data values related to the relative geometry of the mobile communication device and the radio transmitters transmitting the listened to channels; and

a radio transmitter for transmitting said determined data values to said serving base transceiver station.

ABSTRACT

A cellular radio network based positioning system for determining the position of a mobile station (16). For each base transceiver station (1 to 5) or cell of the network, a fixed list of base transceiver stations is stored by a Mobile Positioning Centre (13). Each list identifies those base transceiver stations which enable the position of a mobile station served by the corresponding base transceiver station (6) to be optimally determined. The list is transmitted to the mobile station (16) via the serving base transceiver station (6) and the mobile station determines an observed time difference for each of the listed base transceiver stations, relative to the serving base transceiver station (6), from signals broadcast by the listed base transceiver stations. The observed time differences are transmitted from the mobile station (6) to the serving base transceiver station (6) and are used by the network to compute the position of the mobile station (16).

Figure 4.

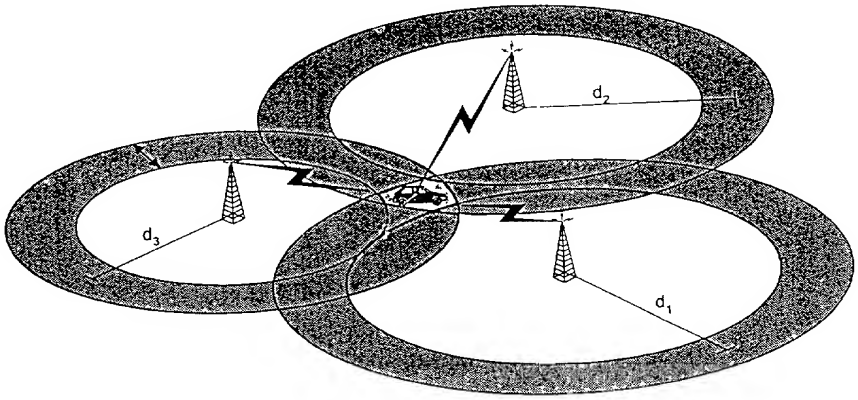


Figure 1

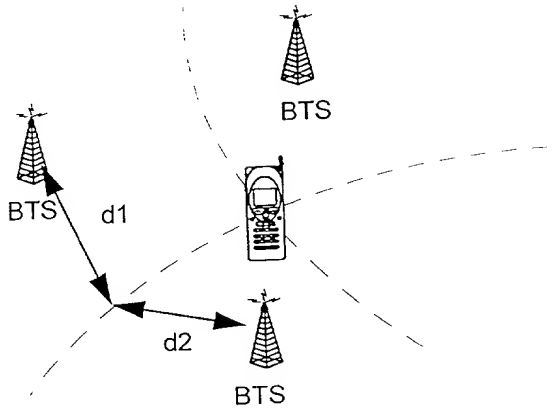


Figure 2

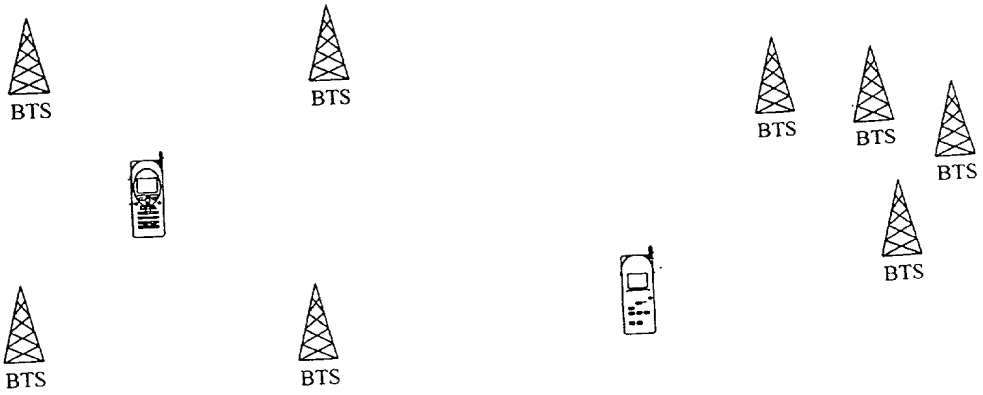


Figure 3

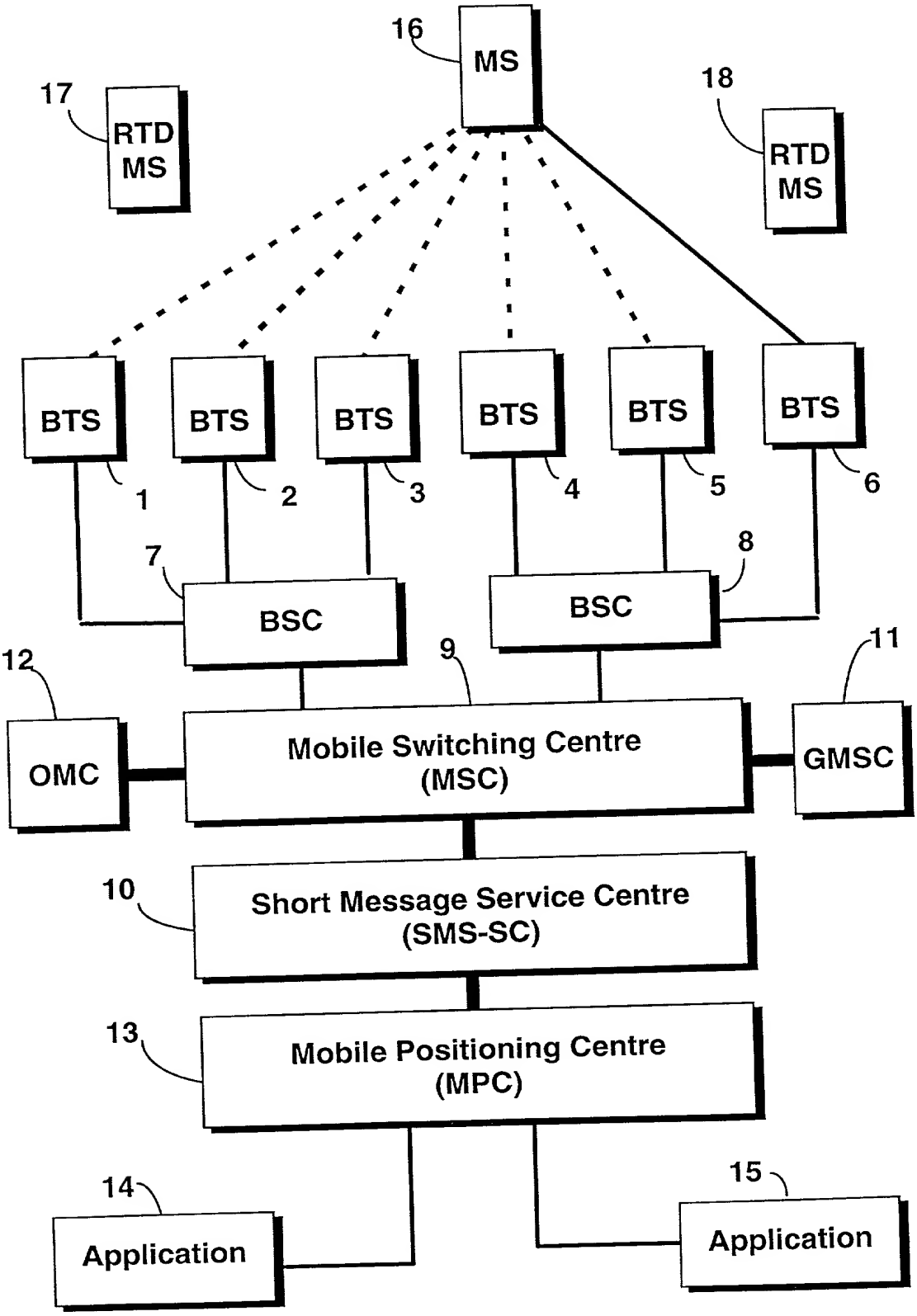

16
MS
17
RTD MS
18
RTD MS
BTS
BTS
BTS
BTS
BTS
BTS
1
2
3
4
5
6
7
8
BSC
BSC
12
9
11
OMC
Mobile Switching Centre (MSC)
GMSC
10
Short Message Service Centre (SMS-SC)
13
Mobile Positioning Centre (MPC)
14
15
Application
Application

Figure 4